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Quality Characterization of Acha-Mushroom Blend Flour and Biscuit

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Abstract

The production and quality evaluation of biscuit made from acha-mushroom flour blends were studied. The biscuits were formulated with 0, 5, 15, and 20% of mushroom (Pleurotus oseotritus) flour with acha four. The biscuits were prepared from the flour blends and evaluated for the proximate composition, phytochemicals, minerals and vitamins, functional, pasting, physical and sensory properties. The carbohydrate content decreases from 67.41-65.03% while the protein, fiber, ash and fat content increases from 5.48-6.39, 1.19-1.49, 2.05-3.06 and 17.22-17.75% respectively with increase in level of mushroom flour addition. Mineral and vitamin content result indicated an increasing level of potassium, phosphorus, magnesium, calcium, vitamin B3, and vitamin C (0.22-0.27, 0.53-0.57, 0.26-0.34, 0.26-0.31, 0.22- 0.27, and 0.56-0.61mg/g) respectively with increasing level of mushroom flour addition. Functional analysis result indicated a decreasing level of oil absorption capacity, Bulk density, and emulsion capacity (11.11-8.33, 0.75-0.60, and 42.42-33.00%) respectively while water absorption capacity and foam capacity increases (50.00-80.00, and 2.00-10.00%) with increasing level of mushroom flour addition. Pasting properties result indicated a decreasing level of trough (136.80-116.80) RVU, pasting time (7.00-5.10) mins, and pasting temperature (72.30-56.80)*C while peak viscosity (216.60-268.10) RVU, breakdown viscosity (79.80-158.50) RVU, final viscosity (327.30-366.70)RVU and set back (190.50-249.90)RVU increases with increasing level of mushroom flour addition. The break strength and weight (2.59-1.52kg and 12.48-11.75g) respectively, decreases while spread ratio (6.59-6.70) of the biscuit samples resulted in a increases with an increase in the level of mushroom flour addition. In sensory evaluation, biscuit containing 5% mushroom four had the highest scores for all sensory attributes except for crispiness. Biscuit containg 20% mushroom flour had score value of 6.70 for crispiness. Addition of mushroom to acha could be said to have greatly improve the quality of acha.

Keyword: Acha; Mushroom; Blend flour; Biscuit; Baked; Schellford; Enriching; Grain

Introduction

Biscuits are baked, edible and commonly flour based products. Biscuits may be regarded as a form of confectionery dried to very low moisture content. The simplest form of biscuit is a mixture of flour and water but may contain fat, sugar and other ingredients mixed together into a dough which is rested for a period, passed between rollers to make a sheet; the sheet is then stamped out, baked cooled and packaged. Generally, biscuits have high fat and sugar levels and at the same time, low water level. The consumption of cereal foods such as biscuits and bread has become very popular in developing nation like Nigeria, especially among children. Biscuits have been classified by into four different categories according to their sugar levels [1]. Soft-dough biscuits containing 25% sugar; digestive with 32% sugar; short cake or flow-type biscuits containing 59% sugar (schellford) and ginger nuts with 79% sugar. The nutritional value of biscuits varies with the type of cereal used. Biscuit is known to generally contain fat (18.5%), carbohydrate (78.23%), ash (1.0%), and protein (7.1%) and salt (0.85%) [2].

Importation of wheat flour has led to high cost of production of baked products, hence locally cultivated and available cereals crop (acha, millet, sorhum) has become a focus alternative in Nigeria [3]. Acha with good baking qualities though relatively low in protein and fiber content is abundantly cultivated in Nigeria [4]. Mushroom which is rich in protein and fiber content also available but underutilize could be used to increase it nutritional value of acha based food products.

Acha has the potential to significantly contribute to whole grain diets, wellness, economic status improvement, and could play an important role in food security in developing economy of a nation like Nigeria. Using mushroom in production of products such as biscuit could improve the nutritional quality of acha food products. In addition, enriching acha flour with mushroom flour could provide a product suitable for diabetes and choleric people. This could encourage local farmers to produce acha and mushroom commercially also; the great potential of mushroom could be fully exploited in enriching other food products.

Acha (*Digitaria exillis*) is a cereal grain in the family of gramineae and commonly referred to as folio or hungry rice [5]. Acha is mostly consumed whole; perhaps because of their small size [6]. Consumption of the grain as whole grain makes it an excellent source of dietary fiber and associated nutraceutical benefits of whole grain suitable for the health conscious and for obesity and diseases, such as diabetes [7-8]. Like other emerging ancient grains, this cereal with excellent culinary and nutritional properties have potential in new product development as it is believed to represent the highest quality of vitamins, minerals, fiber and the Sulphur containing amino acids. Whole acha is now use for quick cooking, non-conventional food products including weaning foods of low bulk density and breakfast cereal with good fiber content [9]. Acha has the potential to contribute significantly to whole grain diets, wellness, economic status improvement, and play important role in food security in developing economy. Whole grain acha flours can be used in the preparation of a number of biscuits and snacks that could be useful for individuals with gluten intolerance [4].

Acha protein have nutritional composition similar to that of white rice [6,10], but having relatively higher sulphur amino acid (methionine and cystine) content [11]. Sulphur amino acids are crucial for proper heart function and nerve transmission, and cereals are an essential source of amino acids for people with low meat intake. In recent study, acha grain has shown to have high water absorption capacity, a property that could be linked to appreciable amount of pentosan. The high-water absorption capacity of acha could be utilized in baked food. Pentosan has been found to be a very important regulator of water absorption and in dough [3].

Mushroom is a macro fungus with a distinctive fruiting body which can be either epigeous (above ground) or hypogeous (underground) and large enough to be seen with the naked eye and to be picked by hand. Studies have shown that tropical mushrooms are highly rich in proteins, minerals, vitamins, crude fiber and carbohydrate with low fat and oil content [12]. The protein content of mushrooms has been reported to be twice that of vegetables and four times that of oranges and significantly higher than that of wheat [13]. The high level of vitamins in mushrooms particularly vitamin C and D has been reported as responsible for its antioxidative activity. Because of the low fat and oil content, they are recommended as good source of food supplement for patients with cardiac problems or at risk with lipid induced disorders [13].

Addition of 285U/kg of phytase (3.125g/kg of agaricius mushrooms) to baking flour enhances the absorption of iron (Fe) fifteen times [14]. Okafor et al. [15] showed that there was significant improvement in the bread protein content and nutritional quality of wheat flour utilised in bread production when oyster (Pluerotus pulmonaris) mushroom powder was added to the wheat. Addition of mushroom (Pleurotus pulmonarius) to cassava starch improved the nutritional content and functional properties.

The research is aimed at characterizing acha-mushroom flour blend and biscuits as a positive way forward in adding value to acha foods.

Materials and Methods

Raw materials

Acha grains (*Digitaria exilis*) were purchased from a local market in Kaduna while mushroom (Pleurotus ostreatus) spawns were purchased from the Biotechnology Division of the Federal Institute of Industrial Research, Oshodi (FIIRO), and Lagos, Nigeria. Baking fats, baking powder, salt and sweet potato (as sweetener) were purchased from Gboko local market in Benue State. Analytical grade chemicals were obtained from food science laboratory, University of Mkar.

Preparation of raw materials

Acha flour: acha grains were cleaned manually by handpicking the chaff and dust. Stones were removed by washing in clean water (sedimentation). The washed and stone freed grains were oven dried at 45 ℃ for 3hours and then milled using milling machine (model R175A). The flour was sieved (0.3mn aperture), packaged (polyethylene) and stored under room temperature.

Mushroom: They were washed thoroughly to remove mud, ferns and other extraneous material before oven dried at 50 ℃. The fruiting bodies were grounded into fine powder, sieved (70 mesh) and stored in tightly stopper bottles prior to further analysis.

Composite Preparation: Acha and mushroom flours were blended at different proportions at (100:0; 95:5; .90:10; 85:15, 80:20 and 100:0%) respectively in order to prepare the composite flours. 100% acha flour served as control (Table1). The blends were thoroughly mixed using Kenwood Blender and packed in polyethene container.

Table 1: Production of Biscuit from Acha-Mushroom Flour Recipe.

Ingredients(g)	AMF	AMF1	AMF2	AMF3	AMF4	WMF
Wheat flour	0	0	0	0	0	100
Acha flour	100	95	90	85	80	0
mushroom flour	0	5	10	15	20	0
Margarine	45	45	45	45	45	45
Sweet potato flour	55	55	55	55	55	55
Water(ml)	80	80	80	80	80	80
Salt	1	1	1	1	1	1
Baking Powder	1	1	1	1	1	1

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Method

Chemical analysis

The crude proteins, ash, crude fiber, crude fat, moisture, minerals and vitamins, and carbohydrate determinations were analysed in accordance with the Association of Official Analytical Chemists [16].

Crude fibre determination: Two grammes (2g) of the ground sample was weighed and placed in a one litre (1l) conical flask. One hundred and fifty millilitres (150ml) of preheated 0.128M Sulphuric acid (H_2SO_4) was then filtered through a fluted funnel and the residue was washed three (3) times with hot water. To the digest, one hundred and fifty millilitres (150ml) of preheated 0.15M Potassium hydroxide (KOH) was being added, and the flask with its' content again heated to boiling temperature. Thereafter, two (2) drops of n-Octnol, which acts as an anti-foaming agent, was added to the flask, and this was further boiled for thirty (30) minutes. This was then filtered, and the residue washed three times with hot water. The filtrate was again washed three (3) times with acetone in a Cold Extraction Unit (Tecator 1615). The resulting residue was then dried in a Carbolite oven for one (1) hour at 150 ℃. This was then cooled in desiccators, ashed (in a muffle furnace at 500 ℃ for 30 minutes), cool and weighed. The percentage crude fibre was calculated

Minerals and vitamin analyses: Total calcium (Ca_2^+) and magnesium (Mg_2^+) contents were determined by EDTA versanate complexometric titration method as described by Harbourne. Sodium (Na^+) and potassium (K^+) ion contents were determined by flame photometry as described by Onwuka [17], phosphorus (P) and sulphur were determined using AOAC method. Duplicate solutions were prepared for each sample and a minimum of three separate readings were taken to minimize error. The mean values were used to calculate the concentrations. The vitamin B2 B3, Folacin, C and vitamin D were determined using the methods described by AOAC [16] methods.

Energy value determination: The energy value was calculated in KJ/100g, using the Atwater Factor Method, as described by Osborne and Voogt. It was calculated using the equation:

$$\text{E.V} = \left[(37 \times \text{Crude Fat \%}) + (17 \times \text{Curde Protein \%}) + (17 \times \text{Carbohydrate}) \right]$$

Functional properties

Water absorption capacity: The method of Onwuka [17] was adopted in the determination of water absorption capacity. One (1g) gram of sample was weighed into a conical graduated centrifuge tube and thoroughly mixed with 10ml distilled water for 30seconds using a warring whirl mixer. The sample was then allowed to stand for 30 minutes at room temperature and then centrifuged at 5,000rpm for 30 minutes. The volume of free water (supernatant) was read directly from the graduated centrifuge tube. Absorption capacity is expressed as grams of water absorbed (or retained) per gram sample.

$$\text{Water absorption capacity} = \text{Amount of water absorbed } (\text{total-free}) \times \text{density } (\text{water})$$

Oil absorption capacity: The method of Onwuka (2005) [17] was adopted in the determination of oil absorption capacity. One (1g) gram of sample was weighed into a conical graduated centrifuge tube and thoroughly mixed with 10ml of oil for 30seconds using a warring whirl mixer. The sample was then allowed to stand for 30minutes at room temperature and then centrifuged at 5,000rpm for 30minutes. The volume of free oil (supernatant) was read directly from the graduated centrifuge tube. Absorption capacity is expressed as grams of oil absorbed (or retained) per gram sample.

$$\text{Oil absorption capacity} = \text{Amount of oil absorbed } (\text{total-free}) \times \text{density } (\text{oil})$$

Emulsifying capacity: The method of Onwuka [17] was adopted in the determination of emulsifying capacity. Two (2g) gram of the flour sample was blended with 25ml distilled water at room temperature for 30seconds in a warring blender at 1600rpm. 25ml of vegetable oil was gradually added after complete dispersion with continued blending for another 30seconds, and then transferred into a centrifuge tube at 1,600rpm for 5minutes. The volume of oil separated from the sample after centrifuging is read directly from the tube. Emulsion capacity is expressed as the amount of oil emulsified and held per gram of sample.

Bulk density: The method of Onwuka [17] was adopted in the determination of bulk density. Bulk densities of samples were determined by weighing 25ml capacity graduated measuring cylinder, gently filling the cylinder with the sample and tapping the bottom of the cylinder on the laboratory bench several times until there is no further diminution of the sample level after filling the 25ml mark. The final volume is expressed as g/ml.

Foam capacity: The method of Onwuka [17] was adopted in the determination of foam capacity. From the powdered sample, 2.00g were weighed, blended with 100cm^3 of distilled water using blender and the suspension was whipped for 5min. The mixture was then poured into a 100 cm3 measuring cylinder and its volume was recorded after 30s. Foam capacity was expressed as percent increase in volume using the formula

$$\text{Volume after whipping - volume before whipping Foam capacity} = \times 100 \text{ Volume before whipping}$$

Physical analysis

Spread ratio: The Spread Ratio was determined by Gomez et al., 1997 [18]. The length and height of three rows and column were measured respectively of six well-formed biscuits. The spread ratio was calculated as diameter divided by height.

Break strength: Method was adapted in determining the break strength. Biscuit of known thickness (0.4cm) was placed centrally between two parallel metal bars (3cm apart). Weights were added on the biscuit until the biscuit snapped. The least weight that caused the breaking of the biscuit was regarded as the break strength of the biscuit.

Pasting properties: Pasting characteristics were determined using a Rapid Visco Analyzer (Model RVA 3D+. Newport Scientific Australia). 2.5g of the sample was weighed into a previously dried canister and 25ml of distilled water was dispensed into the

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canister containing the sample. The suspension was thoroughly mixed, and the canister was fitted into the Rapid Visco Analyser as recommended. Each suspension was kept at 50 ℃ for 1min and then heated up to 95 ℃ with a holding time of 2min followed by cooling to 50 ℃ with 2min holding time. The rate of heating and cooling were at a constant rate of 11.85 ℃ per min. Peak viscosity, trough, breakdown, final viscosity, set back, are read from the pasting profile with the aid of thermocline for windows software connected to a computer.

Sensory evaluation

The sensory evaluation of the samples was carried out for consumer acceptance and preference using randomly selected 20 untrained judges (students and staff of the Department of Food Science and Technology, University of Mkar, Benue State, Nigeria). The panellists were instructed to evaluate the coded samples for colour, crispiness, aroma, taste, texture, and general acceptability. Each sensory attribute was rated on a 9-pointHedonic scale (1= dislike extremely and 9=like extremely). The panellists were offered distilled water to rinse their mouth between evaluations [19].

Photochemical determination

The following phytochemicals were determined according to standard methods; flavonoids, alkaloids, oxalate, phytate, HCN and phenol.

Statistical analysis

The results obtained from the various analyses were subjected to Analysis of Variance (ANOVA) using Statistical Package for Social Sciences (SPSS) version 20.0. Means were separated with Duncan Multiple Range Test (DMRT) at 95% confidence level ($p \leq 0.05$).

Results and Discussion

Proximate composition of biscuits

The results of proximate analysis of the biscuit samples are presented in Table 1. The protein content of biscuits ranged from 5.48 to 6.39%. The 20% mushroom flour protein content is higher than that of 100% acha and 100% wheat. The values indicate that significant difference ($p < 0.05$) exists among the samples. This alteration could be attributed to the addition of mushroom [20]. In this regard, indicated that the addition of mushroom would improve the protein nutritional quality of cookies. Protein is one of the important biomolecules that is essential for proper body functioning, because when digested and metabolized in the body, it provides energy. On the other hand, the carbohydrate content of biscuits ranged from 67.41 to 65.03%. The carbohydrate content of 100% wheat is lower than that of 100% acha and the blends. The carbohydrate content of biscuits decreased with increase in mushroom levels and the effect is significant, ($p < 0.05$). The observed significant decrease in carbohydrates with increase in mushroom may be attributed to the lower content of carbohydrates in mushroom. These findings are in agreement with the results of Feyemi [21] and Adebayo-Oyetoro et al. [22] who indicated that the carbohydrates content decreased with increase in mushroom flour level (mushroom-wheat flour blend).

Moisture content ranged from 6.66 to 7.77%. The moisture content of 100% wheat biscuit was higher than that of 100% acha bisciut and the blends. The effects of the added mushroom showed no significant difference ($p > 0.05$). The moisture content of the biscuits increased (6.66 to 7.77%) with increase in mushroom level. This increase may be due to the increase in protein content from the added mushroom because, protein has been reported to have high affinity for moisture; it may be attributed for the increased moisture content [6,23]. This could also be due to the relatively increase in the fiber content of the added mushroom from the blends. Fiber has the ability of absorbing moisture. The lower the moisture contents of a product, the better the shelf stability of such product [24], because low moisture ensures shelf stability in dried products. Thus, low moisture content in confectionaries such as biscuit is an advantage as it will bring about reduction in microbial spoilage and prolonged storage life if stored inside appropriate packaging materials under good environmental condition. The values obtained in this study favorably compares with those reported by Emmanuel- Ikpeme et al. [25] for different types of commercial biscuits [26] in wheat-potato composite biscuit and in wheat-sweet potato composite biscuit.

The total dietary fibre of 100% acha biscuit was 1.19% which was lower than 1.34% for 100% wheat. The high values obtained might be due to the fact that mushroom used in composite biscuit production were rich sources of dietary fibre which therefore increased the fibre content of the composite biscuit. This agreed with the reports of [27-28]. A high intake of dietary fibre is positively related to different physiological and metabolic effects [29]. Food products that are source of dietary fiber are useful in the prevention and treatment of constipkation, cardiovascular diseases and hypertension.

The ash content increased from 2.05 to 3.06%. The ash content increases with an increase in mushroom levels. The effect of the added mushroom was significant ($P < 0.05$). The high ash content of the composite biscuit might be attributed to the fact that mushroom has been reported to be a good source of minerals. The ash content of a food material could be used as an index of minerals constituents of the food because ash is the inorganic residue remaining after the water and organic matter have been removed by heating in the presence of an oxidizing agent [24].

Fat content ranged from 17.22 to 17.75%. Fat content of the biscuit increased with increment in mushroom addition levels. The effects of the added mushroom were significant ($p < 0.05$). Fat is essential component of tissues and a veritable source for fat soluble vitamins (A, D, E and K). It is able to supply thrice the amount of energy required by the body . It also play a role in determine the shelf-life of foods.

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Phytochemicals

The result of phytochemical composition of biscuit samples are presented in (Table 2). The phenol content of samples ranged from 267.09 to 123.89% and there was a significant difference (P > 0.05) among the samples. The trace quantities of phenolic compounds indicate that the sample could act as immune enhancers, hormone modulators, antioxidant, anti-clothing and anti-inflammatory [30]. The flavonoid content of 100% acha (144.19) was higher than that of 100% wheat biscuit (107.98%) and the blends, there was a significant difference (P<0.05) among the samples. Flavonoids are important antioxidants and promote several health effects. Flavonoids have antioxidant properties that play protective role in the development of cardiovascular diseases, antherosclerosis, hypertension, ischemia/reperfusion injury, diabetes milletus, neurodegenerative diseases (Alzheimer's diseases and Parkinson's diseases), rheumatoid, arthritis and aging.

Table 2: Proximate Composition of Acha-Mushroom Flour Blend Biscuits.

Acha/Wheat (%)	Mushroom (%)	Moisture (%)	Protein (%)	Fibre (%)	Ash (%)	Fat (%)	Carbohydrate (%)
100A	0	6.66^{a}±0.00	5.48^{f}±0.00	1.19^{f}±0.00	2.05^{f}±0.00	17.22^{f}±0.01	67.41^{a}±0.02
100W	0	8.05^{a}±0.00	6.22^{b}±0.01	1.32^{d}±0.00	2.23^{e}±0.01	17.84^{a}±0.01	59.65^{f}±0.02
95	5	7.12^{a}±0.00	5.95^{e}±0.00	1.29^{e}±0.00	2.56^{d}±0.00	17.26^{e}±0.00	65.56^{c}±0.01
90	10	7.53^{a}±0.00	5.99^{d}±0.00	1.44^{c}±0.00	2.76^{c}±0.01	17.42^{d}±0.01	65.50^{b}±0.01
85	15	7.64^{a}±0.00	6.15^{c}±0.00	1.45^{b}±0.00	2.89^{b}±0.00	17.67^{c}±0.00	65.42^{d}±0.01
80	20	7.77^{a}±0.00	6.39^{a}±0.00	1.49^{a}±0.00	3.06^{a}±0.01	17.75^{b}±0.00	65.03^{e}±0.01

Mineral and vitamin

The result for minerals and vitamins composition of biscuits samples seen in Table 3 show that there was significant (P<0.05) difference in potassium content, with the exception of samples containing 100% wheat flour and 10% mushroom flour addition that both recorded the value of 0.24mg/g. Also, the potassium content for 15 and 20% mushroom addition was significantly the same. The higher values of the blended flour might be attributed to appreciable amount of this mineral in mushroom. The value was lower than the 1086.67 to 5350mg/kg for potassium content of high protein fibre snacks reported by Opeoluwa et al. [31]. The difference might be due to variation in flour and other ingredients used. Potassium is an essential nutrient and has important role in the synthesis of amino acid and protein in man. The samples were significantly (P<0.05) different in phosphorus content. However, there was no significant difference in phosphorus content of 15% and 20% mushroom flour addition with a value of 0.56mg/g and 0.57mg/g respectively.

Table 3: Phytochemicals Composition of Acha-Mushroom Flour Blend Biscuits.

Acha/ Wheat (%)	Mushroom (%)	Phenol (Mg/100g)	Flavonoid (Mg/100g)	Hcn (Mg/100g)
100A	0	267.09^{a}±0.01	144.19^{a}±0.01	2.59^{c}±0.00
100W	0	209.04^{b}±0.01	107.98^{b}±1.16	1.77^{f}±0.00
95	5	142.02^{c}±0.01	66.17^{c}±0.00	2.39^{e}±0.00
90	10	134.19^{d}±0.00	56.79^{d}±0.00	2.48^{d}±0.00
85	15	132.91^{e}±0.01	55.31^{e}±0.00	2.69^{b}±0.00
80	20	123.89^{f}±0.00	54.33^{f}±0.00	2.81^{a}±0.00

Phosphorus is the second most abundant mineral in the body after calcium. In form of various phosphates, phosphorus performs a wide variety of essential functions including liberation and utilization of energy from food. The magnesium content of the biscuit samples range from 0.26 to 0.34mg/g. There was no significant (P>0.05) difference in magnesium content of 100% acha (control) and 5% mushroom addition. However, a significant difference (P<0.05) exist among all of the samples. There was no significant (P > 0.05) difference in calcium content of 15 and 20% mushroom addition. Also, the calcium content of 5 and 10% mushroom addition were significantly the same with 100% acha biscuit. Calcium intake in diabetics has been shown to be beneficial and likely to reduce osterophorosis in older diabetics [32].

There was significant (P<0.05) difference in vitamin B3 content of the biscuit samples. The vitamin content of biscuit samples containing 15 and 20% mushroom addition were seen to be significantly the same with 100% wheat biscuit. The vitamin content increases with an increase in mushroom flour addition. This is attributed to the rich deposit of the B vitamins in mushroom. The values are lesser than 0.157 to 0.477mg/100g reported by for ready to eat snacks produced with African bread fruit, cashew nut and coconut flour blends. The B vitamins are needed for carbohydrate and protein metabolism, and are essential for growth, well structuring and functioning of the cells [33]. There was significant (P<0.05) difference in vitamin C content with 100% wheat biscuit having higher value of 0.67mg/100g which was significantly the same with that of 20% mushroom addition. The biscuit samples containing 5, 10 and 15% mushroom addition were significantly the same with 100% acha biscuit. The vitamin C content increases with an increase in mushroom addition level. Vitamin C is a strong water soluble antioxidant that helps the body develop resistance against infectious agents and scavenges harmful.

Functional properties

The functional properties of biscuit samples are presented in Table 4. The water absorption capacity (WAC) of acha flour (AF) was 50.00%, which was slightly lower than 57.14% for

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wheat flour (WF). The blends ranged from 50 to 80%. The WAC showed increase trend with the level of mushroom flour increase. According to Kaur and Sing, flours with high WAC have more hydrophilic constituents, such as polysaccharides. Stated that carbohydrate content decreases the WAC of most food systems. The WAC is the ability of a product to associate with water under limiting conditions in order to improve its handling characteristics and dough making potentials [34-35].

Table 4: Minerals and Vitamins composition of Acha-Mushroom Flour Blend Biscuits.

Acha/Wheat (%)	Mushroom (%)	Potassium (Mg/G)	Phosphorus (Mg/G)	Magnesium (Mg/G)	Calcium (Mg/G)	Niacin B3 (Mg/100g)	Ascorbic-Acid C (Mg/100g)
100A	0	0.22^{c}±0.00	0.53^{ab}±0.01	0.26^{d}±0.00	0.26^{ab}±0.00	0.22^{c}±0.01	0.56^{ab}±0.00
100W	0	0.24^{ab}±0.00	0.51^{c}±0.01	0.14^{e}±0.00	0.18^{c}±0.00	0.27^{a}±0.00	0.67^{a}±0.00
95	5	0.23^{b}±0.00	0.53^{ab}±0.00	0.27^{d}±0.00	0.26^{ab}±0.00	0.24^{b}±0.00	0.57^{ab}±0.00
90	10	0.24^{ab}±0.00	0.54^{ab}±0.00	0.30^{c}±0.00	0.27^{ab}±0.00	0.25^{ab}±0.00	0.59^{ab}±0.00
85	15	0.26^{a}±0.00	0.56^{a}±0.00	0.32^{b}±0.01	0.29^{a}±0.00	0.26^{a}±0.00	0.59^{ab}±0.00
80	20	0.27^{a}±0.00	0.57^{a}±0.01	0.34^{a}±0.00	0.31^{a}±0.01	0.27^{a}±0.00	0.61^{a}±0.28

The oil absorption capacity of acha flour was 11g/g which was much comparable to that of wheat flour. The oil absorption capacity of the blends ranged from 7 to 11g/g. Products with high OAC have the advantage of improving mouth feel and retention of flavour of the food products in which they are incorporated. However, high OAC would be undesirable in some food applications such as those involving deep frying of legume-based products like bean ball (akara). The bulk density of acha flour was 0.75/cm^3, which was slightly lower than 0.81/cm^3 for wheat flour. The bulk density of the blends ranged between 0.65/cm^3 to 0.79/cm^3. The bulk density of flour depends on combined effects of factors such as intensity of attractive inter-particle forces, geometry, particle size and method of preparation. The bulk density of acha flour, wheat flour and the blends indicated that flours have similar particle size which is economical in terms of packaging cost. The low bulk density of flours could be an advantage in the formulation of baby foods where high nutrients density to low bulk is desired. However, high bulk density is a good physical attribute for determining mixing quality of flour.

The forming capacity of AF and WF were 2% and 11%, respectively and varied from 4 to 8% in the blends at the highest level of mushroom addition. The forming capacities were improved by the addition of mushroom. Report showed that that form formation and form stability are a function of the types of protein, pH, processing method, viscosity and surface tension [36]. Highest emulsion capacity (43.90%) was observed in 100% wheat flour. Difference in the emulsion capacity of the flours may be related to their solubility. Hydrophobicity of protein has been found to influence their emulsifying properties [37]. These properties are influenced by many factors among which are solubility, pH and concentration'.

Pasting properties

The pasting properties of the biscuit samples are presented in Table 5. The peak viscosity value ranged from 216.60 to 255.30RVU. The highest value was recorded for 95% acha flour with 5% mushroom flour while the lowest value was recorded for 100% acha flour. There were no significant differences among the biscuit samples ($p > 0.05$) and it was observed that the higher the quantity of the added mushroom, the more the increase in peak viscosity of the flour samples. The peak viscosity is indicative of the strength of pastes, formed from gelatinization during processing in food applications. It also reflects the extent of granule swelling [38] and could be indication of the viscous load likely to be encountered during mixing.

Table 5: Functional Properties of Acha-Mushroom Flour Blends.

Acha/Wheat (%)	Mushroom (%)	WAC (Ml/G)	OAC (Ml/G)	BD (G/Cm3)	FC (%)	EC (%)
100A	0	50.00^{e}±1.00	11.11^{a}±0.01	0.75^{a}±0.01	2.00±1.00	42.42^{a}±0.01
100W	0	57.14^{d}±0.01	11.11^{a}±0.01	0.81^{a}±0.01	11.00^{a}±1.00	43.90^{a}±0.01
95	5	55.23^{d}±0.01	10.90^{a}±0.10	0.77^{ab}±0.01	4.00^{e}±1.00	41.33^{ab}±0.01
90	10	62.90^{c}±0.10	9.76^{ab}±0.01	0.71^{bc}±0.01	6.00^{d}±1.00	40.48^{b}±0.01
85	15	70.90^{b}±0.10	8.90^{b}±0.10	0.67^{cd}±0.01	8.00^{c}±1.00	37.00^{c}±1.00
80	20	80.00^{a}±1.00	8.33^{b}±0.01	0.60^{d}±0.10	10.00^{b}±1.00	33.00^{d}±1.00

The trough value ranged from 136.80 to 116.80RVU. The highest value of the trough was recorded for 100% acha flour while the lowest value of the trough was recorded in 80% acha flour addition with 20% mushroom flour. There were significant differences among the flour samples at ($p > 0.05$) which meant that the higher the quantity of mushroom added, the lesser the trough of the flour samples. Trough thickness measures the smallest capacity of the paste to resist collapse during the period of cooling [39].

The breakdown ranged from 79.80 to 138.50RVU. The highest value of the breakdown was recorded for 90% acha flour added with 10% mushroom flour while the lowest value of the breakdown was recorded in 100% acha flour. There were

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significant differences among the flour samples at (p > 0.05) which meant that the higher the quantity of mushroom substituted, the higher the breakdown values of the flour samples. Breakdown viscosity reflects the stability of the paste during processing. The higher the breakdown in viscosity, the lower the ability of the starch in the flour samples to withstand heating and shear stress during [40]. It was also reported by [41] that high breakdown value indicates relative weakness of the swollen starch granules against hot shearing while low breakdown values indicate that the starch in question possesses cross-linking properties.

Final viscosity value ranged from 327.30 to 366.70RVU while Set back viscosity value ranged from 190.50 to 249.90RVU. The highest value of the final viscosity and setback viscosity was recorded for 80% acha flour added with 20% mushroom flour while the lowest value was recorded in 100% acha flour. The lower setbsack viscosities of acha starches could make it suitable for preparing gels with tendencies to synerese (Jideani and Akingbala, 1993) There were significant differences (P > 0.05) among the flour samples. The final viscosity and setback viscosity increased with an increase in addition of the mushroom flour. Final viscosities are important in determining ability of the flour sample to form a gel during processing while Set back viscosity indicates gel stability and potential for retrogradation. Also reported that high setback value is an indication of the propensity of the starch molecules to disperse in hot paste and re-associate readily during cooling [38,41].

Pasting time value ranged from 7.00min to 5.10min while pasting temperature value ranged from 72.30 °C to 56.80 °C. Pasting time is a measure of the cooking time [40]. A higher pasting temperature indicates high water-binding capacity, higher gelatinization tendency and lower swelling property of starch-based flour due to high degree of associative forces between starch granules [40]. Pasting temperature is one of the properties which provide an indication of the minimum temperature required for sample cooking, energy costs involved and another components stability. Therefore, from the result obtained, 80:20% acha-mushroom samples could be said to cook faster with less energy consumption, thereby saving time and cost.

Physical properties

The physical properties of the biscuit samples are shown in the Table 6. Results showed that there was a significant difference (P<0.05) between each sample in terms of break strength, spread ratio and weight. The spread ratio of the biscuit ranged from 5.82 to 6.82 with minimum value in 100%wheat flour biscuit which indicate that the starches in wheat were highly hydrophilic in nature. From the result it was noticed that the spread ratio increased with an increase in mushroom level of flour.

Table 6: Pasting Properties of Acha-Mushroom Flour Blends.

Acha/Wheat (%)	Mushroom (%)	Peak Viscosity (Rvu)	Trough (Rvu)	Break Down Viscosity (Rvu)	Final Viscosity (Rvu)	Set Back (Rvu)	Peak Time (Mins)	Pasting Tempt (*C)
100A	0	$216.60^f±0.10$	$136.80^a±0.10$	$79.80^f±0.10$	$327.30^f±0.10$	190.50±0.00	$7.00^a±1.00$	$72.30^a±0.10$
100W	0	$233.20^e±0.10$	$131.40^b±0.10$	$111.80^e±0.10$	$338.90^e±0.10$	207.50±0.00	$6.80^a±0.10$	$68.90^b±0.10$
95	5	$259.50^b±0.10$	$126.70^c±0.10$	$132.80^d±0.10$	$337.20^d±0.10$	220.50±0.00	$6.80^a±0.10$	$66.30^c±0.10$
90	10	$268.10^a±0.10$	$124.80^d±0.10$	$143.30^c±0.10$	$356.70^c±0.10$	231.90±0.00	$6.40^a±0.10$	$65.80^c±0.10$
85	15	$239.60^d±0.10$	$120.30^e±0.10$	$149.30^b±0.10$	$361.80^b±0.10$	242.50±0.00	$5.30^b±0.10$	$61.00^d±0.10$
80	20	$255.30^c±0.10$	$116.80^f±0.10$	$158.50^a±0.10$	$366.70^a±0.10$	249.90±0.00	$5.10^b±0.10$	$56.80^e±0.10$

The increase is an indication of the binding properties of the flour and of the texture of the biscuits. The increase in fat content could also affect the spread ratio [42]. The break strength ranged between 2.59g to 1.52g.

The break strength decreased with increase in the level of mushroom flour in the biscuit sample. The decreased could be due to the increase in the percentage of fats (17.22 to 17.75) with increase in mushroom flour added, diluting the protein and carbohydrate level which are the principal compounds responsible for hardness in biscuits [1]. The range of biscuit weight was 12.48 to 11.75g with maximum value in 100% wheat flour biscuits. The weight of the biscuits decreased with increase in mushroom flour. The decrease in weight could be due to the increase in the fat content of the blended mushroom flour, as fat is lighter in weight [42].

Sensory properties of biscuits

Table 7: Physical Properties of Acha Muschroom blend biscuits.

Acha/Wheat	Mushroom	Spread ratio (g/cm)	Break Strength (Kg)	Weight (g)
100A	0	$5.82^d±0.01$	$2.59^a±0.01$	12.480±0.10
100W	0	$5.22^e±0.01$	$2.41^b±0.01$	$13.15^a±0.10$
95	5	$5.80^d±0.01$	$2.39^b±0.01$	$12.32^c±0.10$
90	10	$6.59^c±0.01$	$2.09^c±0.01$	$12.18^d±0.10$
85	15	$6.70^b±0.01$	$1.79^d±0.01$	$12.04^e±0.10$
80	20	$6.81^a±0.01$	$1.52^e±0.01$	$11.75^f±0.10$

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The average mean scores for the sensory evaluation of the biscuits are shown in the Table 7. There was significant different (P>0.05) in their scores for crispiness, aroma, taste, texture and general acceptability of the biscuits while no significant differences (P<0.05) existed in the colour. There was a general decrease in all of the parameters with increase in mushroom except for crispiness and texture which increased. The 100% acha has the higher scores for all the sensory attributes evaluated except taste in which 100% wheat has the highest. The biscuit containing 5% mushroom flour was not significantly different (P>0.05) from the 100% acha in terms of crispiness, aroma and taste but was rated slightly lower than the 100% acha flour biscuit. Based on crispiness, there was no significant difference (P>0.05) from 90:10% (7.65) (acha-mushroom) up to 80:20% (7.70) addition. These three biscuit samples were rated to be the same with 100% wheat biscuit [42-50] (Table 8).

Table 8: Sensory Properties on Acha-Mushroom Blend Biscuits.

Acha/wheat	Mushroom	Colour	Crispiness	Aroma	Taste	Texture	General Acceptability
100A	0	$7.35^{a}\pm0.67$	$7.25^{ab}\pm1.29$	$7.25^{a}\pm1.06$	$7.10^{a}\pm1.51$	$6.65^{c}\pm1.22$	$7.05^{a}\pm1.05$
100W	0	$7.05^{a}\pm1.27$	$6.85^{a}\pm1.46$	$6.30^{ab}\pm1.52$	$7.35^{a}\pm1.22$	$6.75^{b}\pm1.40$	$6.90^{a}\pm0.91$
95	5	$7.25^{a}\pm1.19$	$7.50^{ab}\pm1.63$	$6.55^{ab}\pm1.57$	$6.75^{ab}\pm1.61$	$6.80^{b}\pm1.83$	$7.00^{a}\pm1.65$
90	10	$7.15^{a}\pm1.22$	$7.65^{a}\pm1.11$	$6.15^{b}\pm1.34$	$6.05^{b}\pm1.19$	$7.20^{a}\pm1.52$	$6.50^{a}\pm1.15$
85	15	$7.10^{a}\pm1.20$	$7.65^{a}\pm1.51$	$5.80^{b}\pm1.60$	$6.00^{b}\pm1.71$	$7.25^{a}\pm1.51$	$6.25^{b}\pm1.43$
80	20	$7.00^{a}\pm1.45$	$7.70^{a}\pm1.45$	$5.75^{b}\pm1.92$	$5.70^{b}\pm1.92$	$7.35^{a}\pm1.84$	$6.25^{b}\pm1.91$

There was no significant difference (P>0.05) in aroma from 90:10% (6.15) (acha-mushroom) up to 80:20% addition (5.75). The products were like slightly. Since aroma is a determining factor in consumer's acceptance of biscuit it can be deduced that the biscuit is accepted up to 10% addition of mushroom. The only handicap is the slight aroma of the off flavour that was still noticed in mushroom. The taste result showed that the 100% wheat flour biscuit had the highest mean score of 7.35, there was no significant difference (P>0.05) from 90:10 (6.05) (acha-mushroom) up to 80:20 addition (5.70). This result has proved that these three samples were equally accepted in terms of taste of the biscuit samples. The texture of the biscuits were fairly accepted and there was no significant difference (P>0.05) in texture from 10% up to 20% mushroom addition. Biscuit containing 5% mushroom addition was significantly the same with that of wheat biscuit while a significant difference (P<0.05) occurred between them and all other samples [50-52].

From the result of overall acceptability of the biscuit samples, there was no significant difference (P>0.05) between samples containing 15 and 20% mushroom addition also the biscuit containing 5% mushroom addition was rated to be the same with 100% acha (control) in the general acceptability. This is an indication that the improvement was acceptable to the consumers.

Conclusion

The result of this study showed that addition of mushroom flour improved the quality of protein, fiber, ash, minerals and vitamins content. The 90:10% acha-mushroom blends was the most preferred sample with a corresponding increment of 9.31, 21.0 and 34.63% in terms of protein, fiber and ash content respectively. The texture and crispiness of the biscuit were improved. Addition of mushroom to acha could be said to have also added variety to diabetes meals and other individuals that are non- tolerant to gluten protein.

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